Hong Kong's temperature record: Is it in support of global warming?

香港的溫度記錄: 全球暖化的證據?

Wyss W.-S. Yim 嚴維樞教授

Department of Earth Sciences, The University of Hong Kong / School of Energy & Environment, City University of Hong Kong

香港大學地球科學系 / 城市大學能源與環境學院

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Plan 內容

3 parts 部分：

(1) Background 背景

(2) Hong Kong's temperature record
香港的溫度記錄

(3) Implications/conclusions 影響 / 結論

Some questions to be answered

要回答的幾個問題

When was Hong Kong's present day temperature last exceeded?

香港上次超過現時的溫度是那時？

Can natural variability and human impact be identified from the record?

從記錄中,可否分別那些是自然變異或人為的影響？

What is important in causing the changes?

造成這種變化的重要因素是什麼？

Are there more important drivers other than carbon dioxide?

是否存在比二氧化碳更重要的原因？

What are the implications for achieving greater environmental sustainability?

達到大環境的可持續性有什麼意義?

Components of the Earth's system
地球系統的組成部分

- **Atmosphere (air)** 大氣（空氣）
- **Hydrosphere (groundwater, lakes, rivers & oceans)**
- 水文圈（地下水，湖泊，河流和海洋）
- **Cryosphere (ice)** 冰凍圈（冰）
- **Biosphere (living things including humans)**
- 生物圈（生物，包括人類）
- **Pedosphere (soil)** 土壤圈（泥土）
- **Lithosphere (solid Earth)** 岩石圈（固體地球）

Climate change is a product of astronomical forcing including solar variability and interactions with the above components

氣候變化是天文力量所產生，其中包括太陽變化及其與上列因素的相互作用

Advantages in studying the present day
現今研究上的優勢

Most reliable record -
最可靠的記錄

Instrumental Record
儀器記錄

Information age
信息時代

Direct observations e.g. clouds, particulates and aerosols
直接觀察, 例如雲, 微粒和氣溶膠

Satellite observations since ~1980
自1980年開始的衛星觀測

Some temperature statistics in Hong Kong (source: Hong Kong Observatory)

一些香港的溫度數據

（來源：香港天文台）

Annual mean temperature 年平均溫度	**↑ 0.12°C per decade; 1.44°C (1885-2009)**
Mean diurnal range 平均晝夜溫差	**↓ 0.24°C per decade (1947-2009)**
Mean sea level (Victoria Harbour) 平均海平面（維多利亞港）	**↑ 26 mm per decade (1954-2009)**

Note – Based on HKO Headquarters Station except where stated.

注意 - **除**特別註明外，**以上**資料是**根據香港天文台總部測站**。

Temperature record studied

溫度記錄的研究

1853-1880	Royal Engineers, Harbour Office, etc. (NOAA Peterson & Vose 1997)
1884-1939	Hong Kong Station*
1947-2010	Hong Kong Station*

*Hong Kong Observatory Headquarters Station near Nathan Road.

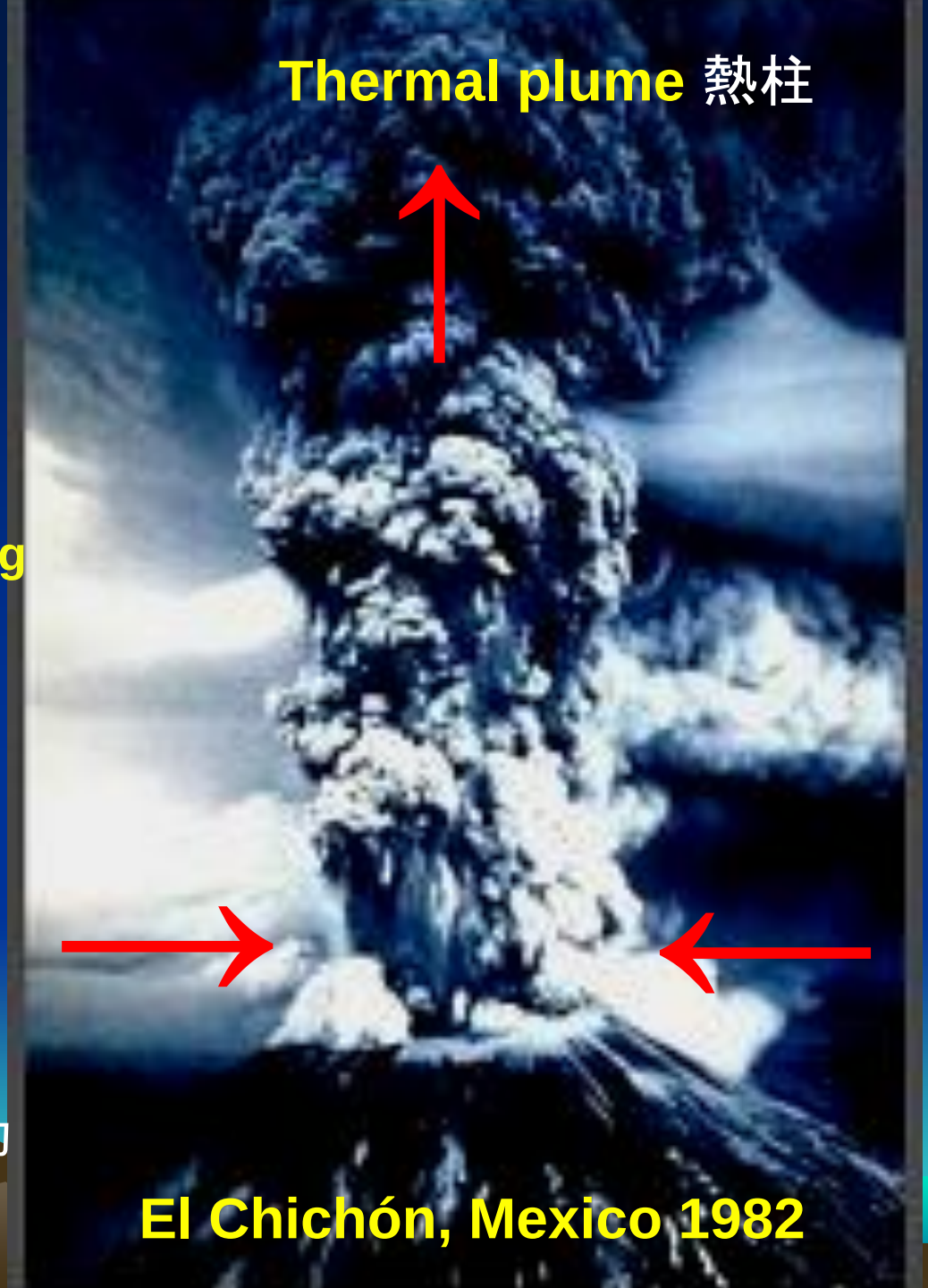
*香港天文台總部測站。

Volcano Model

火山模型

Ash & aerosols reduces solar Radiation leading to cooling
灰和氣溶膠降低太陽能輻射,導致冷卻

Warm air stores more moisture – water vapour Redistribution
暖空氣儲存更多的水分 - 水蒸氣再分配



Eruption changes normal air circulation Pattern
火山噴發改變正常的空氣流通慣性

Cool air stores less Moisture
冷空氣存儲較少水分

Cool air 冷空氣

Impact longer lasting if major
如較大,影響可以更持久

Main impacts of 'major' volcanic eruptions

"規模大"火山噴發的主要影響

(1) **Initial rise in temperature of the stratosphere followed by cooling of the troposphere.**

平流層溫度首先上升, 之後流層冷卻。

(2) **Eruption clouds obstruct the incoming solar radiation causing the Earth's surface temperature to decrease.**

噴發的火山灰阻礙太陽輻射, 導致地球表面溫度下降。

(3) **The thermal plumes will interfere with the Earth's 'normal' air circulation.**

熱柱會干擾地球的"正常"氣流。

Main impacts of ‘major’ volcanic eruptions

“規模大”火山噴發的主要影響

(4) **Transfer of water vapour from the troposphere into the stratosphere.**

水蒸氣從對流層進入平流層。

(5) **Particulates and aerosols in the atmosphere form condensation nuclei.**

微粒和氣溶膠在大氣中形成冷凝結核。

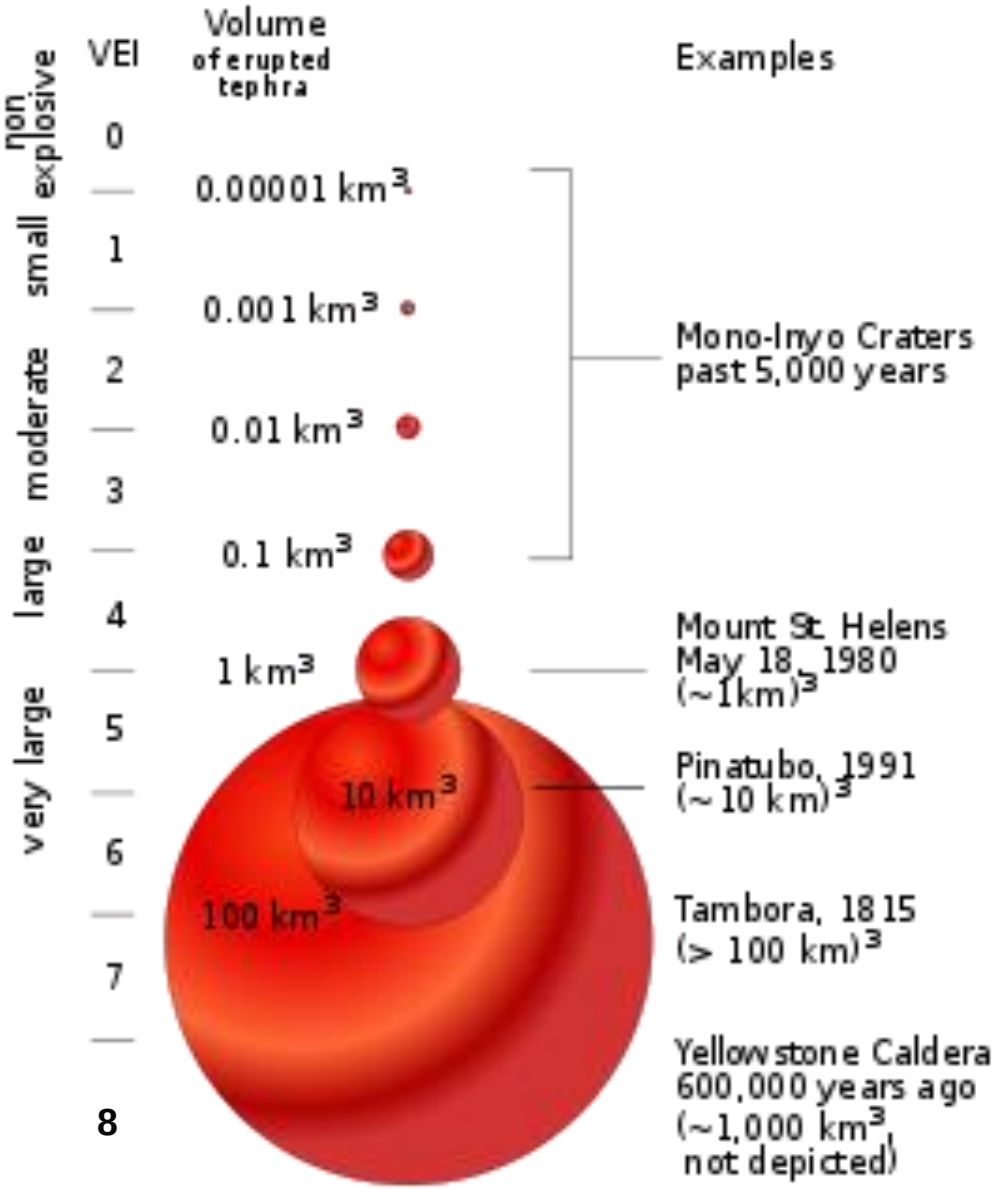
(6) **The sulphur oxides released lead to acid precipitation which damage vegetation.**

釋放硫氧化物, 導致酸雨, 破壞植被。

Volcanic Explosivity Index (VEI)
火山爆炸性指數

after Newhall & Self (1982)

Scale for measuring volcanic eruptions



List of 13 ‘major’ volcanic eruptions since 1883 showing their location, main eruption date, volume of tephra and ranking. (Source: Global Volcanism Program)

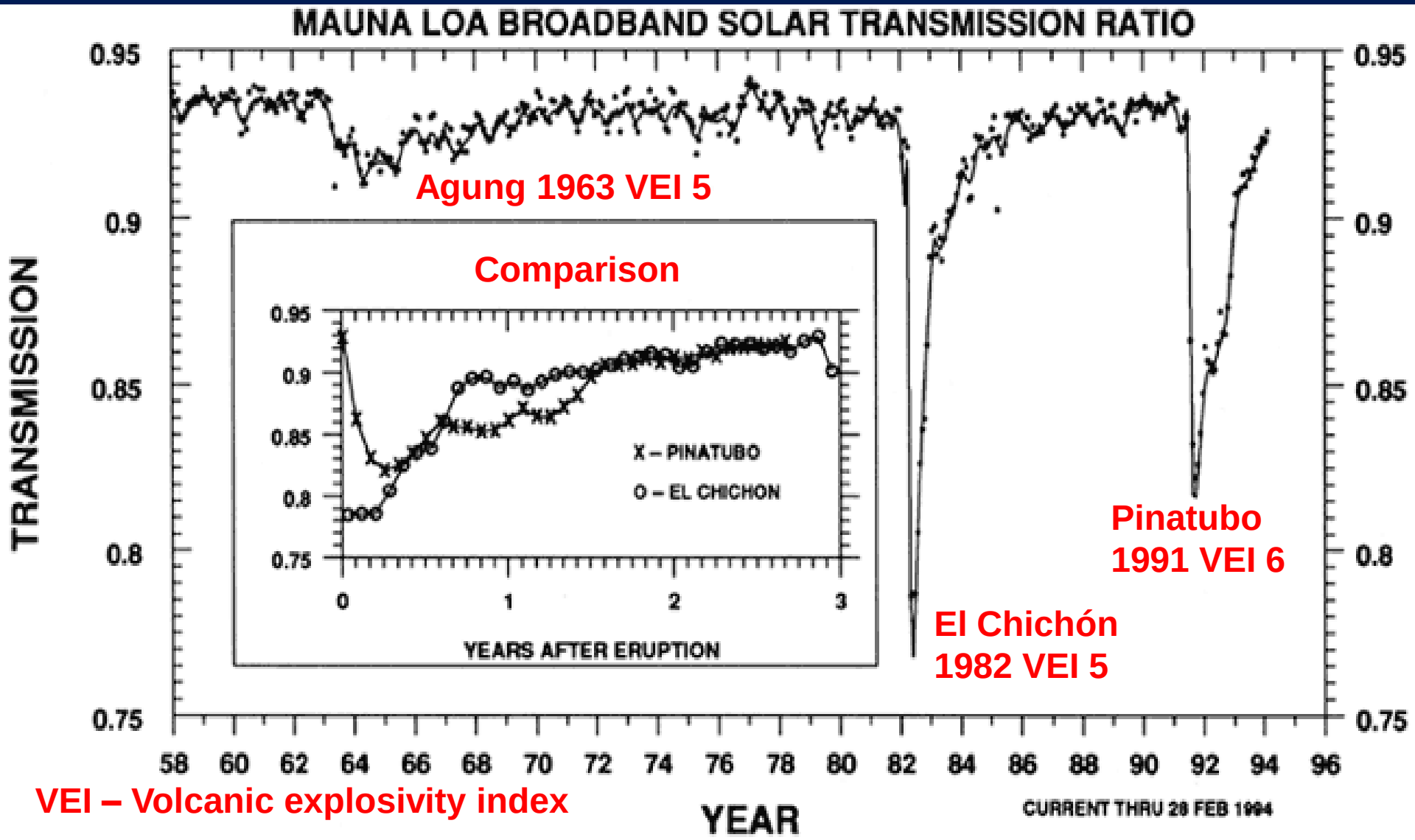
自1883年以來 13次‘主要’火山爆發清單
它們的位置，主要噴發的日期，火山灰數量和排名。

Volcano	Latitude & longitude	Main eruption date	VEI	Volume of tephra	Rank.
Krakatau, Indonesia	6°6’6”S 105°25’22”E	August 17, 1883	6	$2.0 \pm 0.2 \times 10^{10} m^3$	=2
Okataina, New Zealand	38°7’0”S 176°30’0”E	June 10, 1886	5	$2.0 \times 10^9 m^3$	10
Santa Maria, Guatemala	14°45’21”N 91°31”6”W	October 24, 1902	6?	$2.0 \times 10^{10} m^3$	=2
Ksudach, Russia	51°48’0”N 157°9’24”W	March 28, 1907	5	$2.4 \times 10^9 m^3$	8
Novarupta, USA	58°16’0”N 155°9’24”W	June 6, 1912	6	$2.8 \times 10^{10} m^3$	1
Cerro Azul, Chile	35°19’12”S 70°45’39”W	April 10, 1932	>5	$9.5 \times 10^9 m^3$	5
Kharimkotan, Russia	40°7’0”N 154°30’30”E	January 8, 1933	5	$1.0 \times 10^9 m^3$	13
Bexymianny, Russia	55°58’22”N 160°35’12”E	March 30, 1956	5	$2.8 \times 10^9 m^3$	7
Agung, Indonesia	8°20’30”S 115°30’30”E	March 17, 1963	5	$>1.0 \times 10^9 m^3$	12
St. Helens, USA	46°12’0”N 122°11’0”W	May 18, 1980	5	$1.2 \times 10^9 m^3$	11
El Chichón, Mexico	17°21’36”N 93°13’40”W	April 4, 1982	5	$2.3 \times 10^9 m^3$	9
Pinatubo, Philippines	15°8’0”N 120°21’0”E	June 15, 1991	6	$1.1 \pm 0.5 \times 10^{10} m^3$	4
Cerro Hudson, Chile	45°54’0”S 72°58’0”W	August 12, 1991	5	$4.3 \times 10^9 m^3$	6

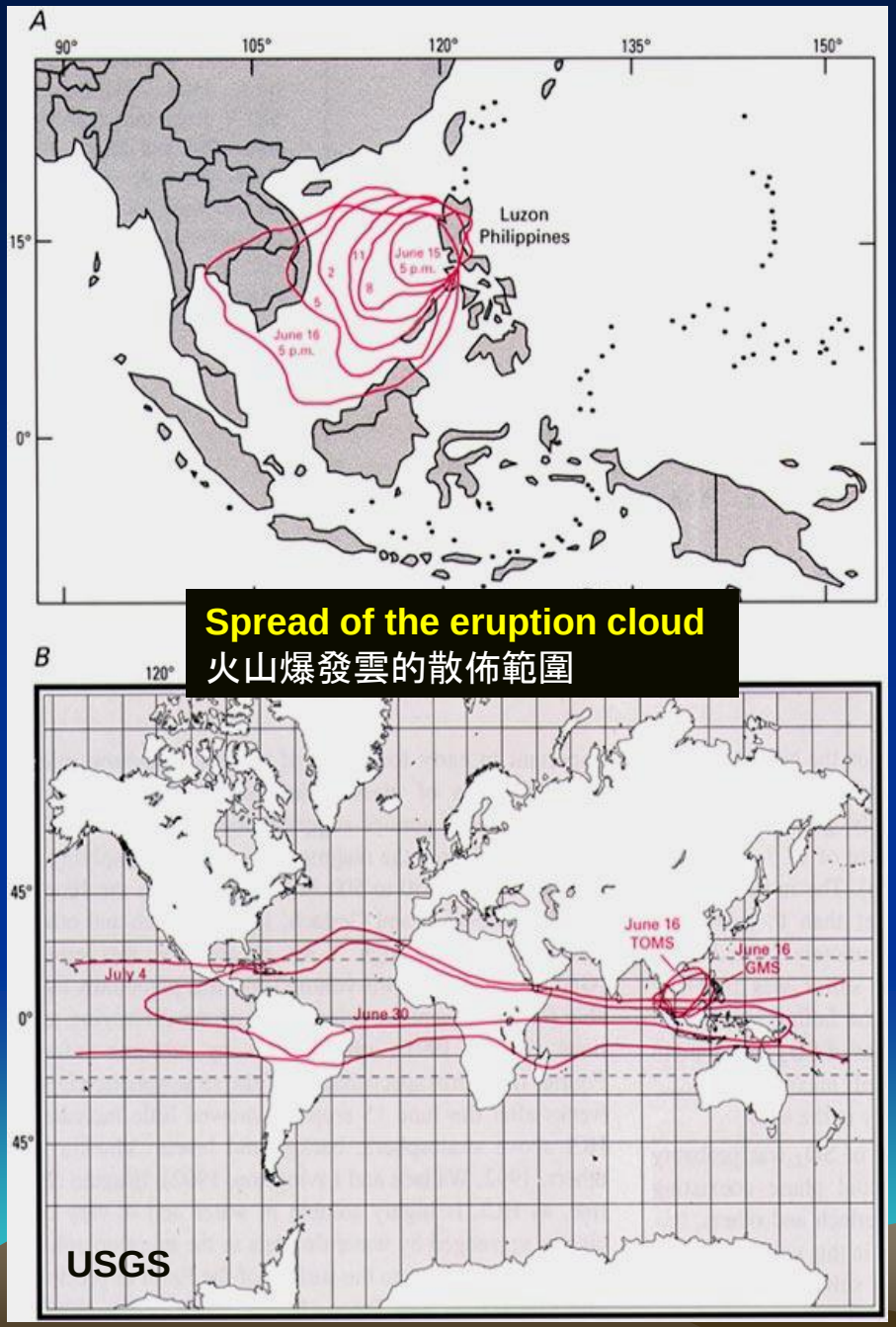
Location of Agung, El Chichón and Pinatubo

Agung, El Chichón 和 Pinatubo 的位置

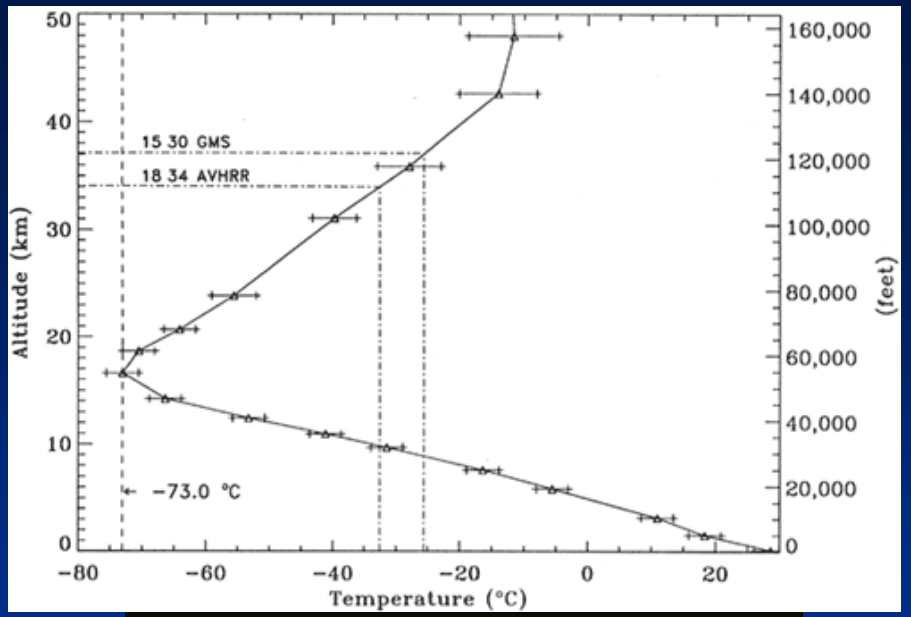
Solar radiation record during the 3 volcanic eruptions
3次火山爆發時的太陽輻射記錄



VEI – Volcanic explosivity index



Spread of the eruption cloud
火山爆發雲的散佈範圍



Temperature gradient above ground
地面溫度漸層

Double layer of Pinatubo ash over South America on August 8, 1991 (Space shuttle photo)
1991年8月8日在南美上空 觀察到雙層的皮納圖博火山灰 (太空穿梭照片)

Hong Kong's population in 1841 and the number of years taken for the population to increase to and by 1 million
(*Source: Census and Statistics Department*)
1841年香港人口及每增長100萬人所需時間

Year 年	Population 人口	No. of years 所需的年數
1841	7500	-
1937	1 million (百萬)	> 97
1950	2 million	14
1959	3 million	10
1971	4 million	13
1979	5 million	9
1994	6 million	16
2009	7 million	16

Drilling into the seafloor has led to the discovery of higher temperatures than the present

海底鑽探發現 從前的溫度比現在的溫度較高

~0.5 million year record of climate & sea-level change in Hong Kong

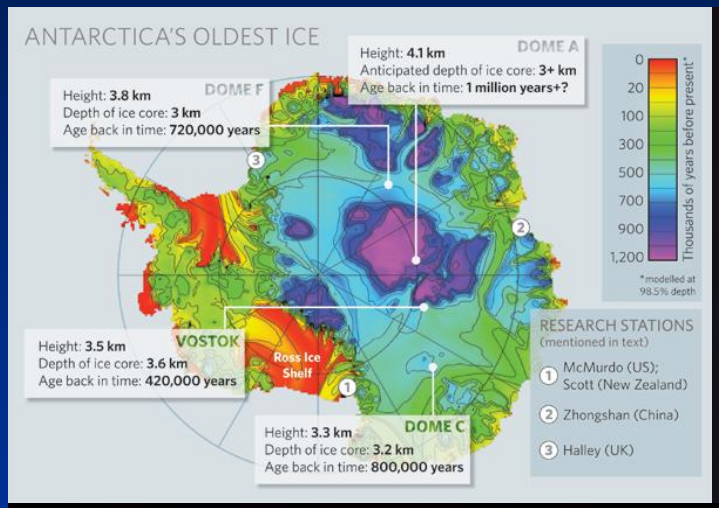
50萬年以來香港的氣候記錄與海平面變化

Unit 單位	Age 年代	Estimated age (ka) 估計年齡	Marine isotope age 海洋同位素年齡	Dating method used 測年方法	Maximum thickness (m) 最大厚度
M1	Postglacial	< 8.2	1	^{14}C	21.5
T1	Last glacial	8.2 – 70	2-4	OSL	6.5
M2	Last interglacial	90 – 140	5	U-series	15.7
T2	2nd last glacial	150 – 180	6	-	9.5
M3	2nd last interglacial	190 – 240	7	-	12
T3	3rd last glacial	250 – 300	8	T-L	7.3
M4	3rd last interglacial	310 – 340	9	U-series	14.1
T4	4th last glacial	350 – 370	10	-	6
M5	4th last interglacial	380 – 420	11	U-series	3.5
T5	5th last glacial	> 440	12	-	7

M – marine; T – terrestrial

Agreement with temperature record shown by deuterium in Antarctica ice cores

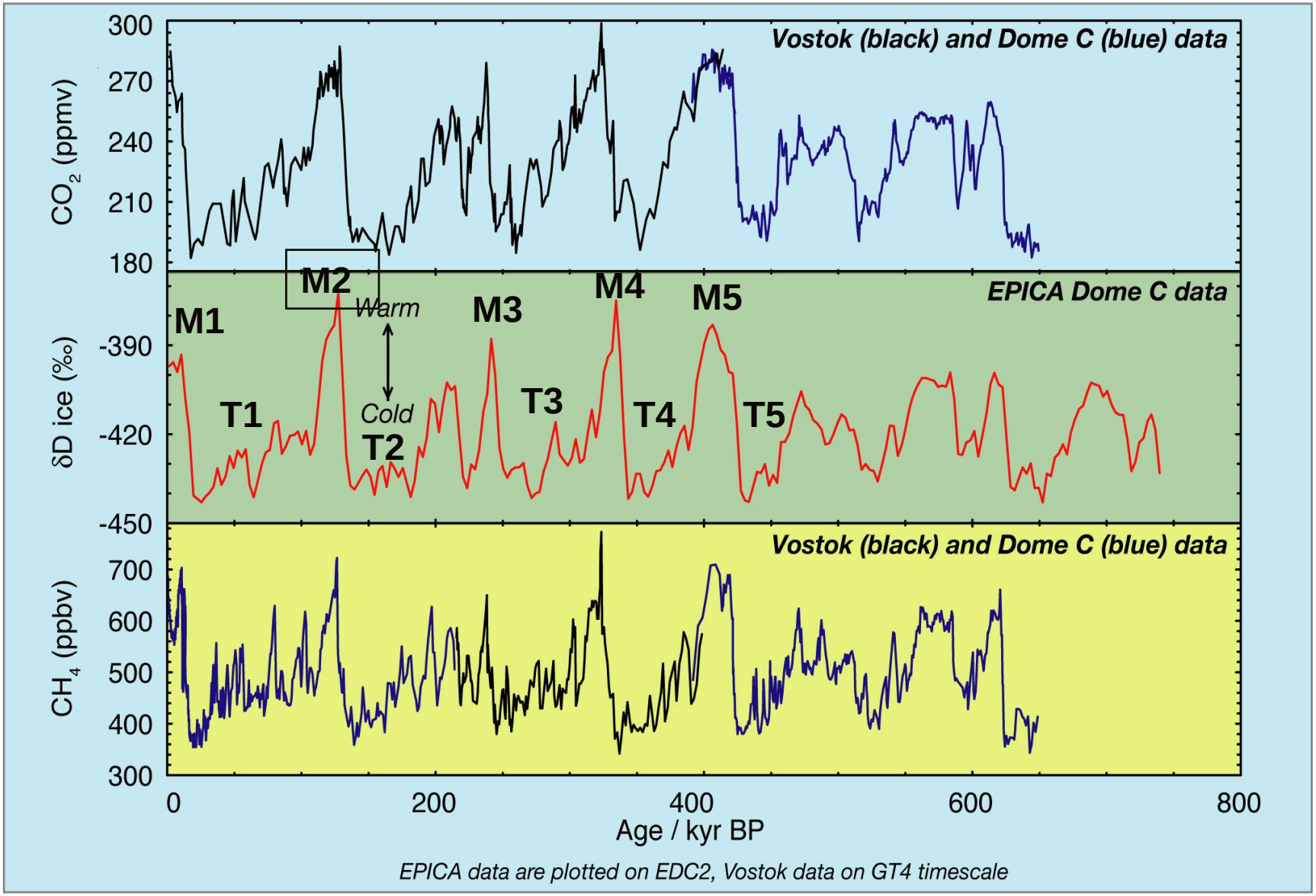
在南極洲冰芯中, 氘顯示的溫度記錄



Annual banding in ice

週年冰條帶

Antarctic ice core records: Vostok and EPICA CO_2, CH_4 and δD



GLOBAL CHANGE IGBP

Petit et al., 1999 (Vostok), Siegenthaler et al., 2005 (Dome C - CO_2), Spahni et al., 2005 (Dome C - CH_4), EPICA community members, 2004 (δD)

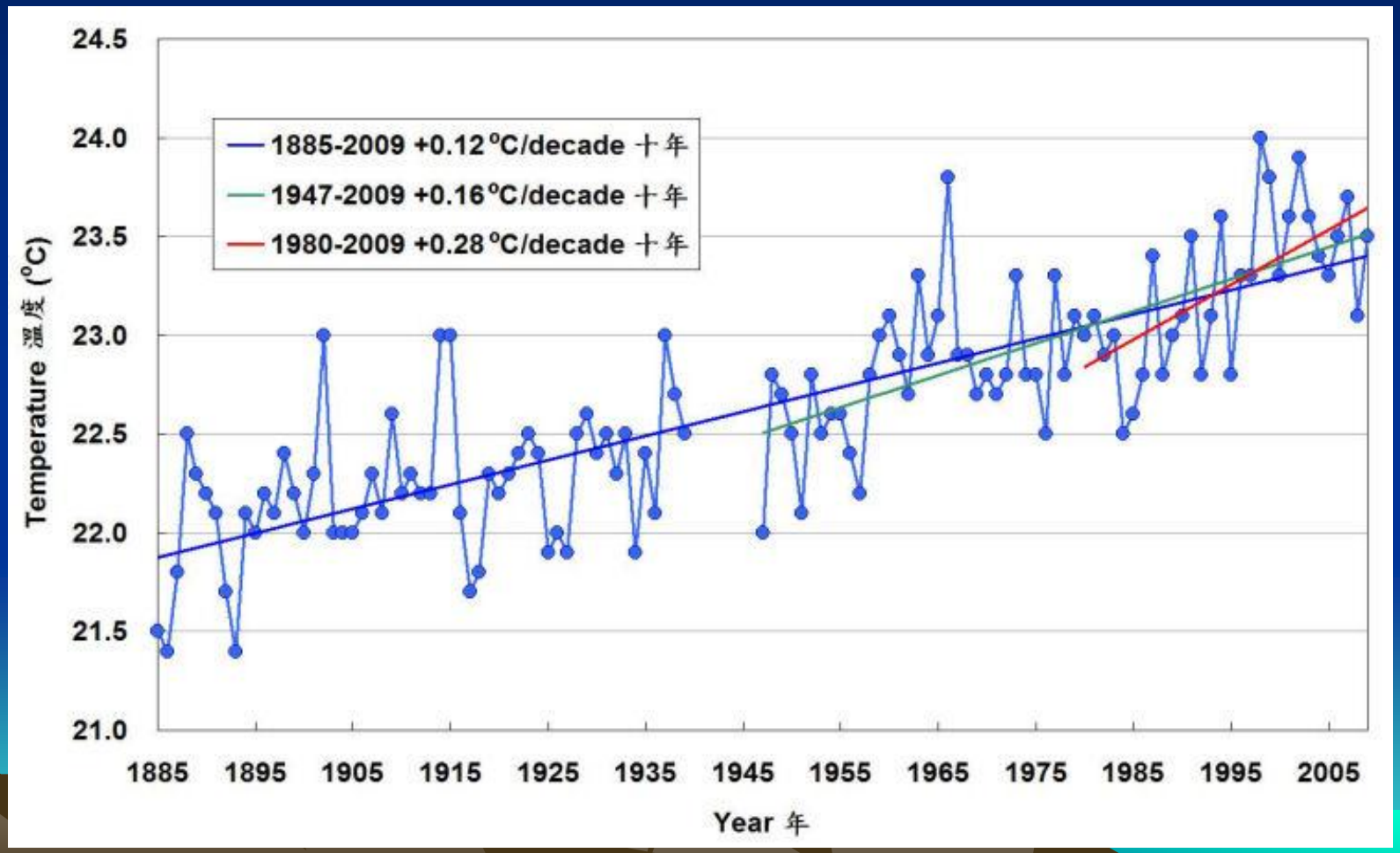
PAGES PAST GLOBAL CHANGES

Mangrove pollen *Sonneratia* sp.
Present day northern limit Hainan Island
紅樹林花粉 *Sonneratia* sp. 現今出現在最北的地方是海南島

Present in the M2 unit of the New Hong Kong Airport site. This indicated the last time present day temperature in Hong Kong was exceeded was about 130,000 years ago during the last interglacial period. The mean annual temperature of ~26^{o}C at the time was 2-3^{o}C higher than in the present day.

Hong Kong's temperature record at the Hong Kong Station (Source: Hong Kong Observatory)

香港站的香港溫度記錄 (資料來源:香港天文台)



Location map of the Hong Kong Station and the Waglan Island Station of the Hong Kong Observatory

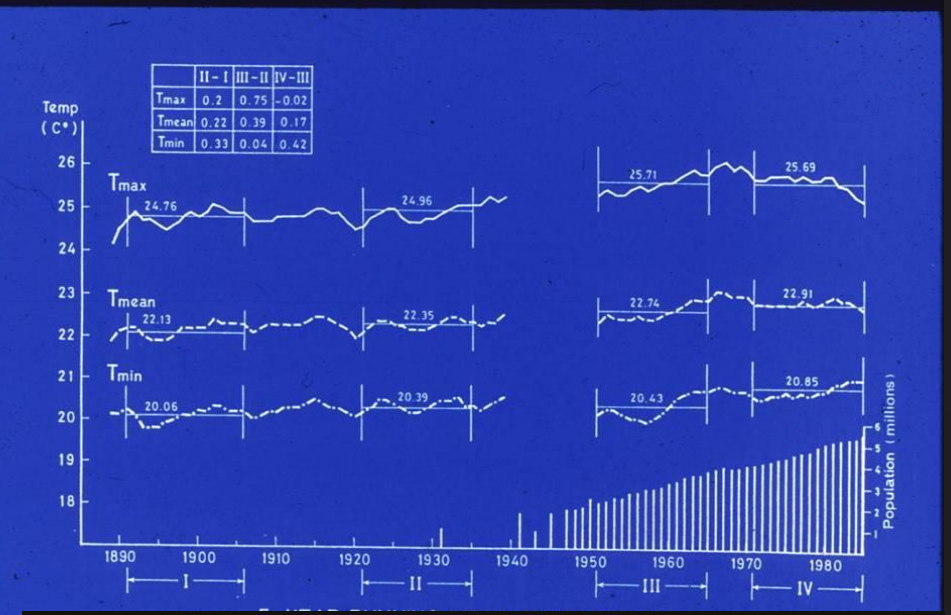
香港天文台香港站和橫瀾島站的位置圖

Comparison between the two stations
兩個站之間的比較

	Hong Kong Station 香港站	Waglan Station 橫瀾站
Record available 可用記錄	1884-1939; 1947-2010	1968-2010
Location 位置	Urban (~4 million) 市區	Rural (few inhabitants) 郊區
Ground elevation 海拔	32 m	57 m
Urban heat Island (UHI) 城市熱島	Known to be strongly affected (Koo 1988) 已知有強烈影響	Absent 沒有
Temperature record (Leung et al. 2004) 溫度記錄	Temperature record shows most positive linear regression (r=0.79) 顯示了最正線性回歸	Least positive linear regression (r=0.127) 顯示最少正線性回歸

Comparsion between the temperature record of the Hong Kong Station and the Macau Station (Source: Koo 1988)

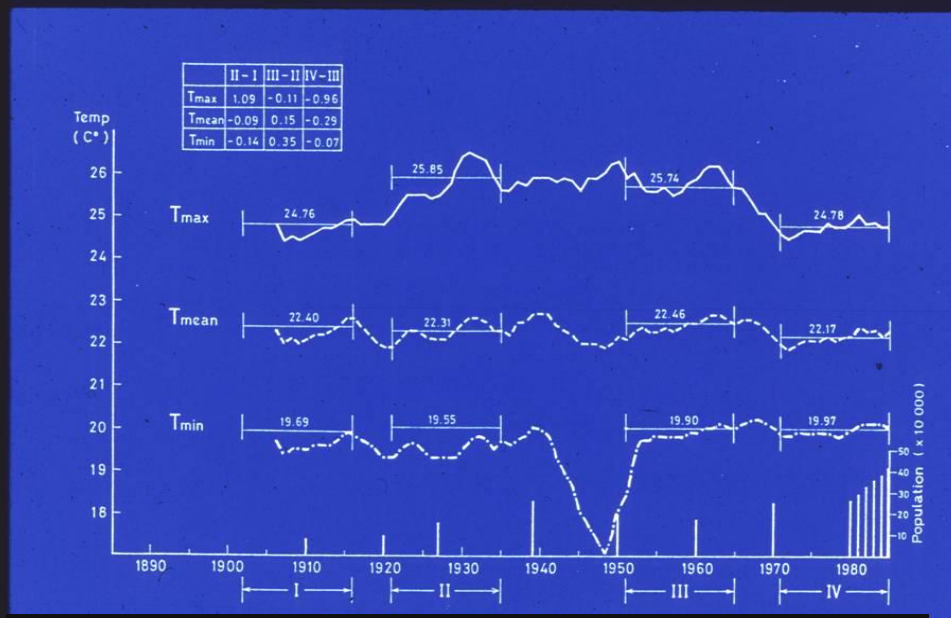
香港站和澳門站, 溫度記錄之間的比較



Hong Kong

5-year running mean temperatures at Hong Kong Station, Nathan Road (located in a heat trap area because of the topography of Victoria Harbour)

在香港站(彌敦道), 5年平均氣溫



Macau

5-year running mean temperatures at Macau station (hill top location) No obvious temperature rise can be observed

在澳門站, 5年平均氣溫

Source of heat for UHI at the Hong Kong Station
在香港站的熱來源

The obvious source is NOT CO_2 which is one of the greenhouse gas but …

最明顯的來源不是二氧化碳(溫室氣體)…

Heat generated through human activities including power generation, transportation (including by air, land and sea), land use changes, constructional activities, air conditioning, water pumping, cooking, usage of home applicances, fireworks, etc.

而是通過人類活動而產生的熱量，包括發電，交通，土地利用變化，施工活動，空調，泵水，烹飪，使用家庭電器，煙花爆竹

Top 11th hottest years in terms of mean annual temperature recorded at the Hong Kong Station since record began in 1884
自1884年開始, 香港站最暖的11年平均溫度記錄

Year 年份	Mean temperature (°C) 平均氣溫	Rank 排名
1998	24.0	1st
2002	23.9	2nd
1999	23.8	=3rd
1966	23.8	=3rd
2007	23.7	5th
2003	23.6	=6th
2001	23.6	=6th
1994	23.6	=6th
2009	23.5	=9th
2006	23.5	=9th
1997	23.5	=9th

10 years showing the greatest temperature difference between the Hong Kong Station and the Waglan Station during the period 1968-2010
香港站與橫瀾站10年最大溫差顯示

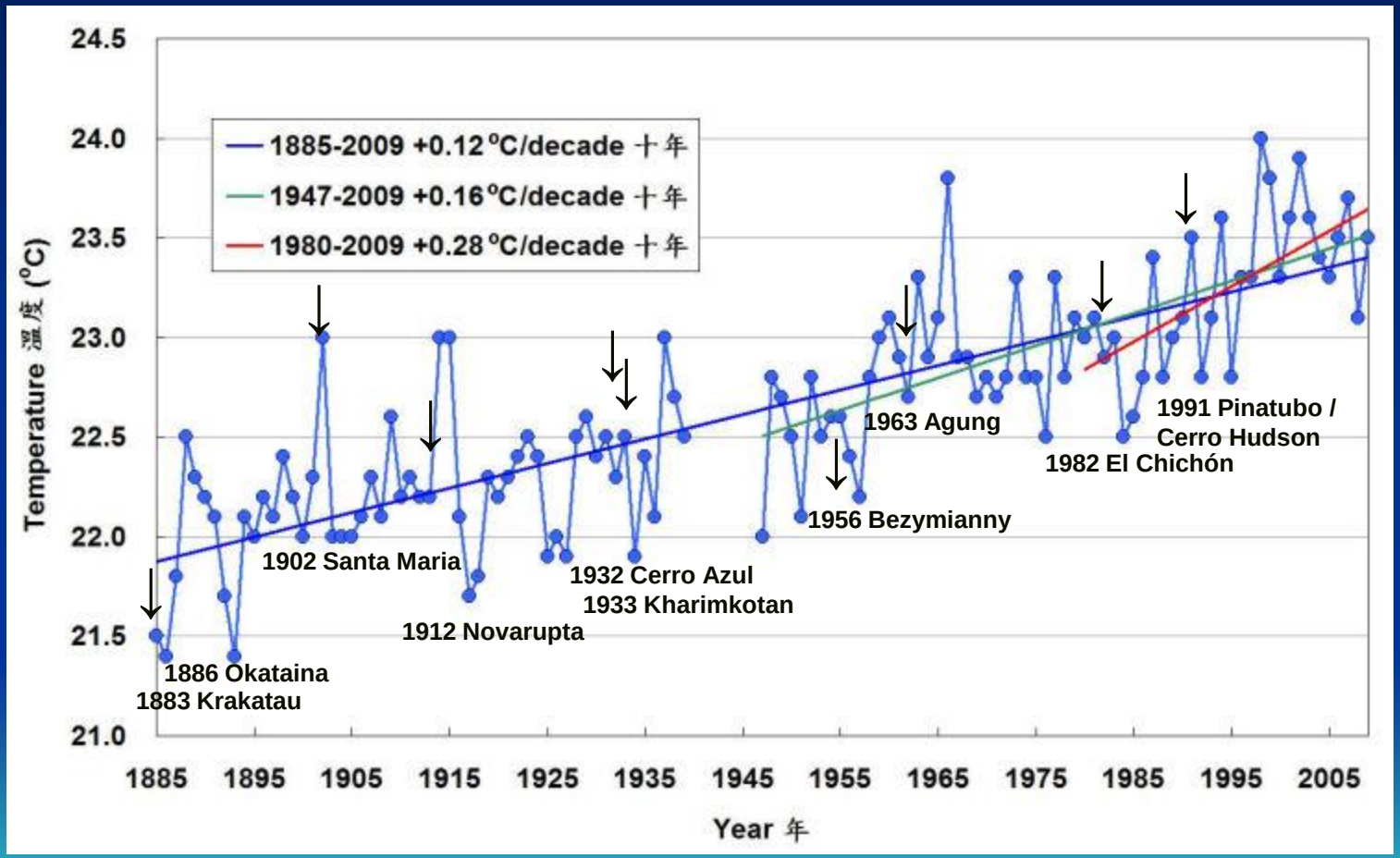
Year 年份	Difference (°C) 溫差	Explanation 說明
1997	1.6	Pre-handover infrastructure development 回歸前的基礎設施建設
1994	1.5	" "
1995	1.5	" "
1998	1.3	
1996	1.3	" "
2005	1.1	
1999	1.0	
2000	0.9	
1991	0.9	Early stage of pre-handover infrastructure development
1970	0.8	回歸前基建的前期階段

Top 12th coldest years at the Hong Kong Station since record began in 1884

自1884年開始, 在香港站11年來最冷的平均氣溫記錄

Year 年份	Mean temperature °C 平均氣溫	Rank 排名	Explanation 說明
1884	21.3	1st	1883 Krakatau eruption cooling
1886	21.4	=2nd	1883 Krakatau eruption cooling and 1886 Okataina eruption cooling
1893	21.4	=2nd	" " " "
1885	21.6	4th	" " " "
1887	21.7	=5th	" " " "
1892	21.7	=5th	-
1917	21.7	=5th	-
1918	21.8	8th	-
1903	21.9	=9th	1902 Santa Maria eruption cooling
1925	21.9	=9th	-
1927	21.9	=9th	-
1934	21.9	=9th	-

Selected major volcanic eruptions and cooling
主要的火山爆發和冷卻



Estimate of temperature increase after correction for UHI based on 1968-2010 temperature values

1968年至2010年, 校正熱島影響後, 估計增加的溫度

	HKO Headquarters*	Waglan
Mean temperature平均溫度	23.14°C	22.50°C
Temperature difference 溫差	+0.64°C	-0.64°C
Maximum temperature最高溫度	24°C (1998)	23.2°C (2002)
Minimum temperature最低溫度	22.5°C (1976)	21.3°C (1995)
Temperature range溫度變化	1.5°C	1.9°C
Suggested correction修正建議	- 0.5°C (for UHI)	
Actual warming實際變暖	0.14°C (< 25% increase)	

* Mean annual temperature 1884-1939 and 1947-2010 is 22.62°C.

1884-1939年與1947年至2010年的平均氣溫是22.62°C.

Environmental sustainability implications
環境可持續發展的影響

Good news 好消息 –
Rate of warming is much slower than what is claimed (IPCC/HKO)
變暖的速度比聲稱的慢得多

CO_2 is not as bad as claimed 二氧化碳不是那麼糟糕
In terms of fossil fuels coal has the greatest reserves by far
在化石燃料方面,煤炭具有最大的存量

Bad news 壞消息 –
Ice is melting because heat is generated through human activities
人類活動所產生的熱量引致冰融化

Natural variability (including volcanic eruptions) is a problem
自然可變性(包括火山爆發)是一個問題

Abnormally dry and wet years are bad for food production
異常乾旱和多雨的年份不利糧食生產

Environmental sustainability implications
環境可持續發展的影響

Bad news 壞消息 –

Underestimated the role of water vapour as a greenhouse gas (saturated greenhouse gas hypothesis of Ferenc Miskolczi)

低估水蒸氣作為一種溫室氣體的作用

'Water pollution' through human impact on the natural water cycle is a major problem

"水污染", 人對自然水循環的影響, 是一個大問題

Electricity will become more expensive because HK is phasing out coal for power generation

電力將變得更加昂貴, 因為香港逐步淘汰燃煤發電

UHI is a contributor to the local air pollution problem

城市熱島對本地空氣污染問題是一個原因

Low carbon will not solve the problem of climate change

低碳不會解決氣候變化問題

Top 10 carbon footprint nations in 2001
Hertwich & Peters (2009)
在2001年, 碳排放量前10名的國家

Country	Footprint tCO_2e/p	Population million	Domestic share %
Luxembourg盧森堡	33.8	0.4	56
Hong Kong香港	29.0 (6*)	7.0	17
USA美國	28.6	277.5	82
Singapore新加坡	24.1	3.3	36
Australia澳洲	20.6	19.4	82
Canada加拿大	19.6	31.2	75
Switzerland瑞士	18.4	7.2	36
Finland芬蘭	18.0	5.2	69
Netherlands荷蘭	16.7	16.0	53
Ireland愛爾蘭	16.0	3.8	56

* 2008 level excluding trade-linked emission (HK's Climate Change Agenda) .

Can we learn from Singapore?

2010 HSBC Economy and Climate Change survey of 15 countries based on at least 1000 consumers/country (www.channelnewsasia.com)

我們可以借鑒新加坡嗎？

- **12% climate change is top concern (4th lowest after France, UK and USA)**

  ”氣候變化是最關注的問題”佔12% (第四最低, 排在法國, 英國和美國之後)

- **28% stability of global economy is the top concern**

  ”穩定的全球經濟是最關注的問題”佔28%

- **22% terrorism is the top concern**

  ”恐怖主義是最關注的問題”佔22%

- **67% more spending on healthcare compared to global average of 56%**

  ”關注醫療開支”佔67%, 全球平均為 56%

- **53% more spending on boosting economy compared to global average of 38%**

  ”關注增加消費以刺激經濟”佔53%, 全球平均為 38%

Some observed temperature and rainfall changes in Hong Kong (source: Hong Kong Observatory)

在香港，一些關於溫度和降雨量變化的觀察

Annual mean temperature ↑ **0.12°C per decade; 1.44°C (1885-2009)**

年均溫度

Overestimated due to UHI 由於UHI,過於高估

Mean diurnal range ↓ **0.24°C per decade (1947-2009)**

平均日差

Shows UHI is important 顯示 UHI 是重要的

Mean sea level (Victoria Harbour) ↑ **26 mm per decade (1954-2009)**

平均海平面（維多利亞港）

Implications uncertain 不確定的影響

Annual rainfall ↑ **51 mm per decade (1947-2009)**

年雨量

Heavy rain days (> 30 mm per hour) ↑ **0.4 days per decade (1947-2009)**

暴雨的日數（每小時>30毫米）

Combined effects of natural & human causes

結合自然和人為原因的影響

Temperature Conclusions溫度結論

(1) **The Hong Kong Station is unsuitable for indicating long-term temperature trends unless it is adequately corrected for UHI.**

香港站的資料是不適合用作顯示溫度長期變化的趨勢，除非它適當地調整熱島效應。

(2) **Heat produced by human activity should be blamed as the cause of warming rather than CO_2.**

人類活動所產生的熱量而不是二氧化碳，引致氣候變暖

(3) **Volcanic eruptions, a natural cause of temperature variability, have been shown to cause cooling.**

火山爆發 - 溫度變化的自然因素，已被證明可導致溫度下降。

Temperature Conclusions氣溫結論

(4) **At least 75% of the temperature rise seen in the record of the Hong Kong Station since 1884 may be attributed to UHI while no more than 25 % may be attributed to global warming.**

自1884年以來, 在香港站的記錄至少有75%的溫度上升可能是由於城市熱島效應, 不超過 25%可以歸因於全球變暖。

(5) **Engineering construction through 'large' scale infrastructure development was the probable cause for the sharp temperature increase at the Hong Kong Station during the 1990s.**

20世紀 90年代, 在香港站的大規模基建發展是可能導致溫度急劇上升的原因。

General Conclusions 綜合結論

(1) Variability in the hydrological cycle through natural means (volcanic eruptions) and human impact (water pollution) is a much underestimated cause of climate change.

在水文循環中, 自然和人爲因素的影響被大大低估, 這都可以是氣候變化的成因。

(2) Reducing CO_2 level only is an ineffective means of slowing down global warming.

減少二氧化碳去減緩全球暖化, 效果有限。

(3) Overpopulation is a problem.

人口過多是一個問題。

General Conclusions 綜合結論

(4) **The rapid development of infrastructures immediately before the handover of Hong Kong was an important contributor to warming during the 1990s.**

在90年代香港回歸前, 迅速的基建發展嚴重引致溫度上升。

(5) **Water vapour in the atmosphere is probably rising in tune with temperature changes.**

大氣中的水蒸氣很可能隨著溫度的變化而增加。

(6) **Climatic models should be treated with caution because they cannot predict decadal variability.**

應謹慎研究氣候模型，因爲它們無法預測年代間的變化。

Closing quote 結語

The planet's fine … 地球還很好

Overpopulation is threatening human survival
人口過多正影響人類的生存

We're the ones we have to worry about (T. Nield)
我們要擔心的應該是我們自己

Thank you
謝謝